Innovative Intersections

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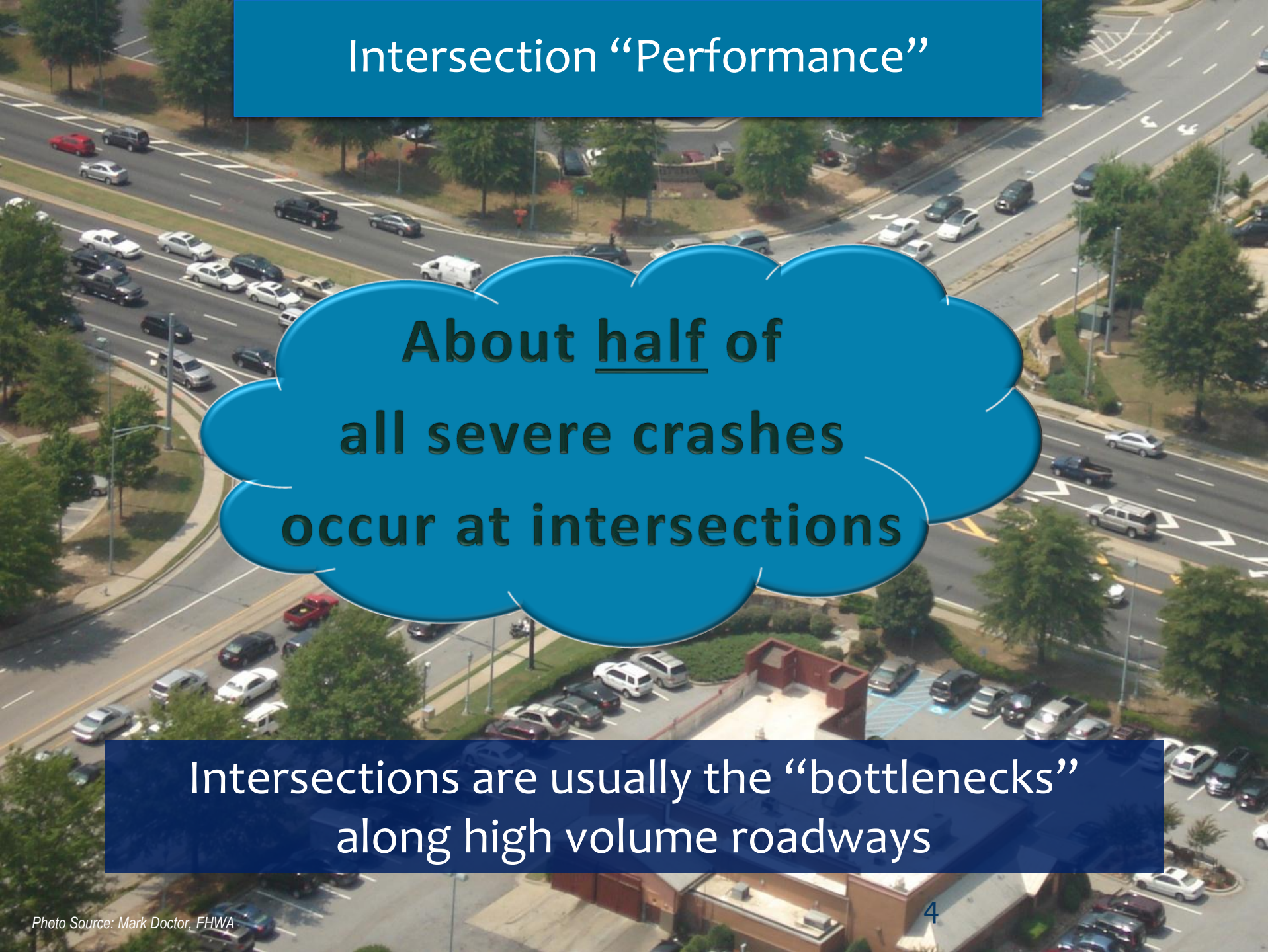
What are the challenges?

- Increasing Congestion
- Too Many Crashes
- Providing for all modes
  - Bicycles, Pedestrians, Transit
- Not Enough Funding
- Inability for More Right-of-Way
- Reduce Impacts of Projects
  - Environmental, social, economic

Bigger is not always better

Changing the way we design intersections may allow us to save lives and build more efficient and effective projects

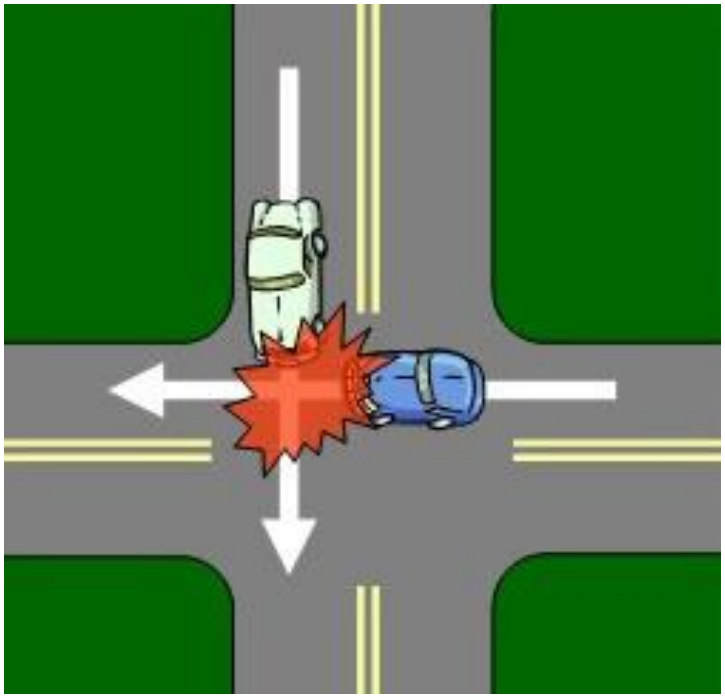
Intersection "Performance"



Intersections are usually the "bottlenecks" along high volume roadways

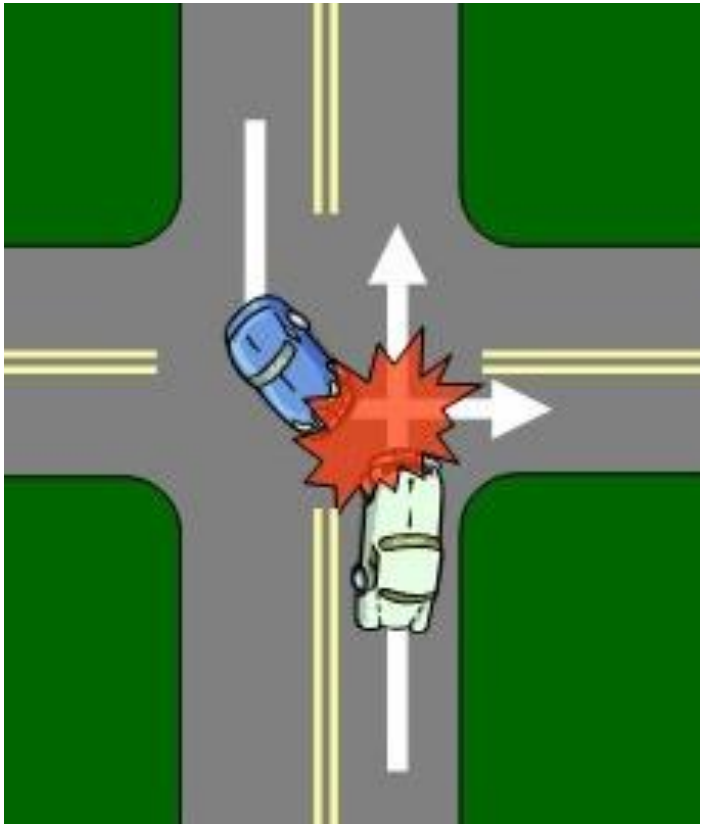
Photo Source: Mark Doctor, FHWA

Intersection Safety Facts



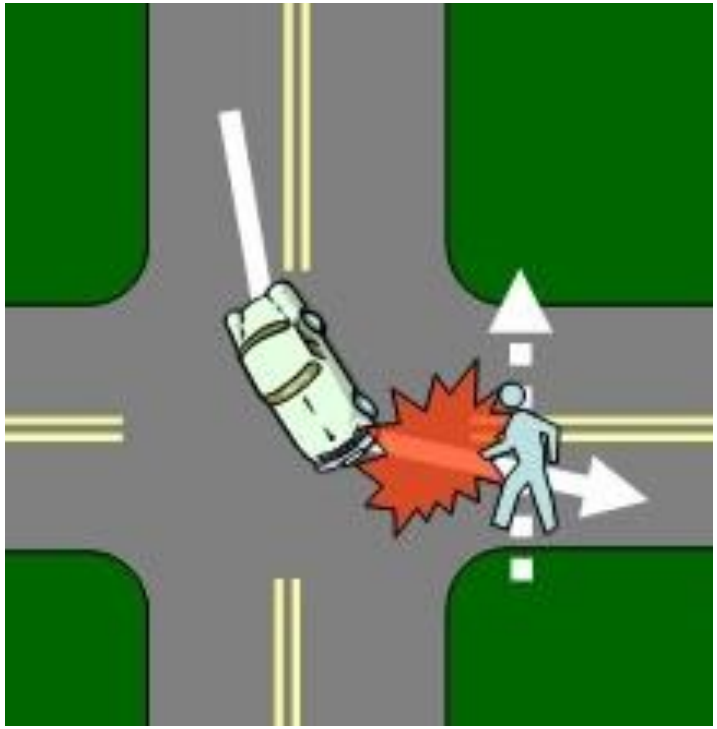
Angle crashes account for over 40% of fatal crashes at intersections

Intersection Safety Facts



Left turn crashes account for over 20% of fatal crashes at intersections

Intersection Safety Facts



Ped & Bike crashes account for 25% of fatal crashes at signalized intersections

Benefits of innovative designs

SAFER – they can improve the way traffic makes certain movements by eliminating, relocating or modifying conflict points

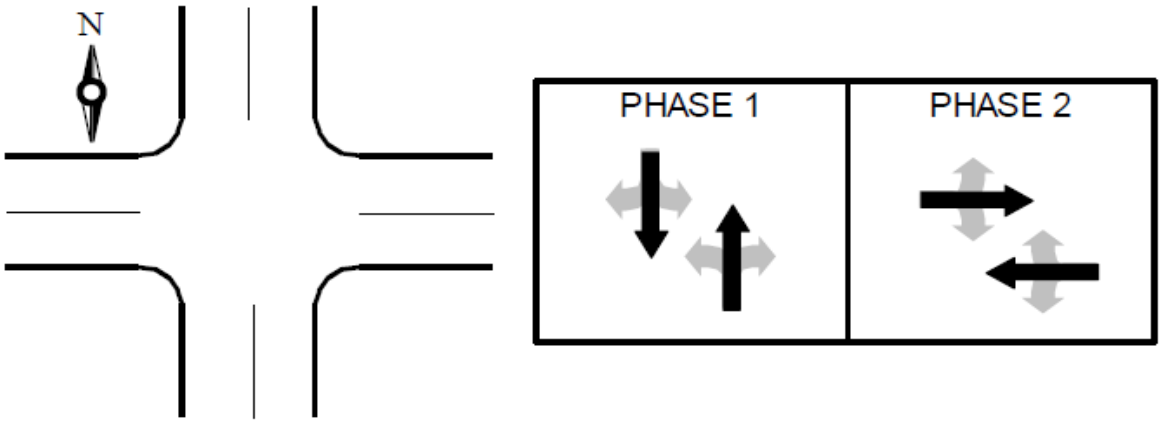
LESS DELAY – reducing the number of signal phases

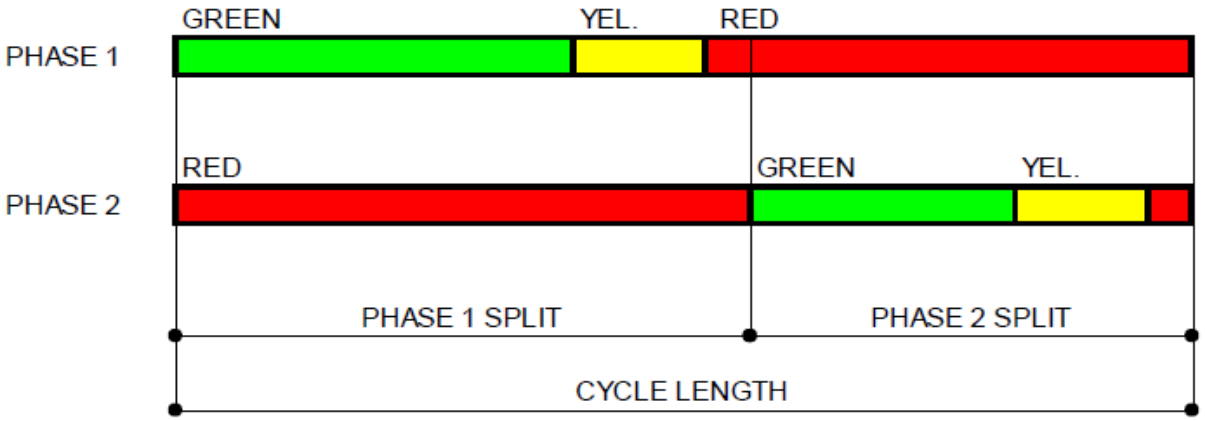
LOWER COST – $$$


Source: Mark Doctor, FHWA


Source FHWA

Signal phasing



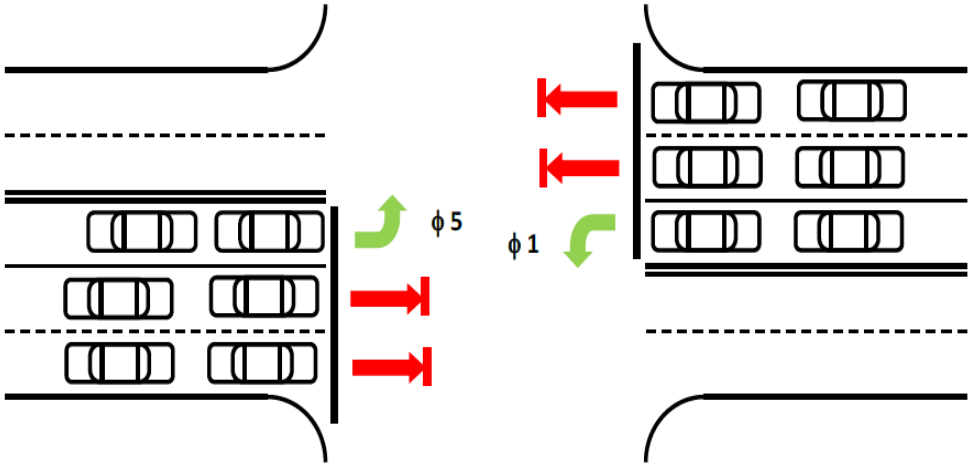


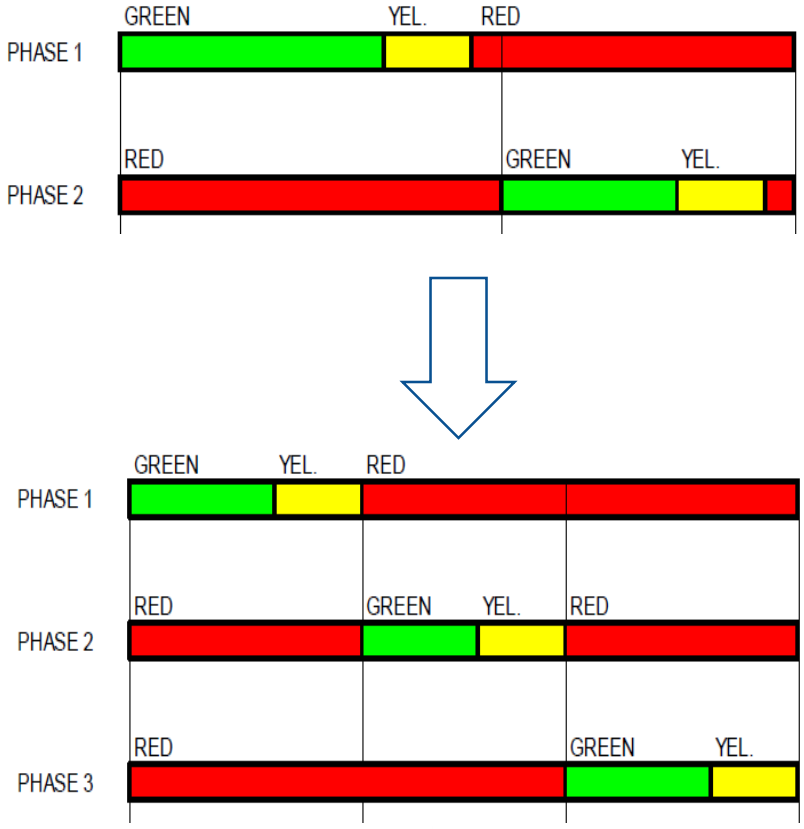
Basic two-phase signal operation

Source: MnDOT Traffic Signal Timing and Coordination Manual

Signal phasing

Adding "protected" left-turn phases is common as volumes increase



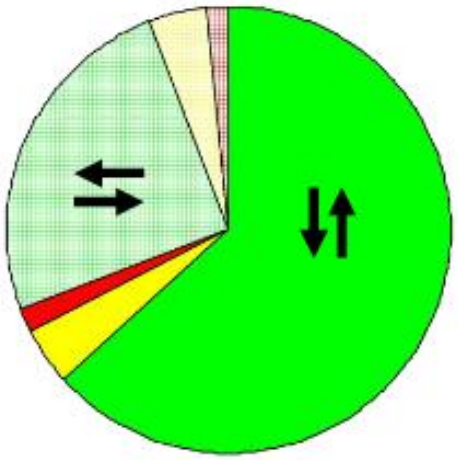


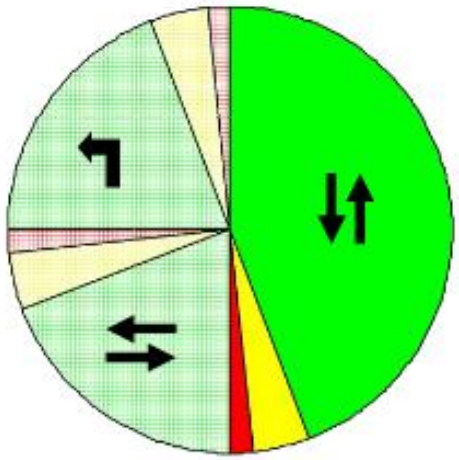
Source: MnDOT Traffic Signal Timing and Coordination Manual

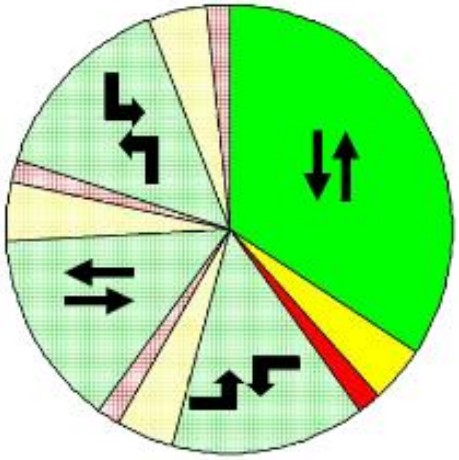
Signal phasing

Adding more phases “steals” time away from the major through movement and can increase intersection delays

- More phases also add more “lost time”







Signal phasing

4 Phase Signal				
	Minor Street	Minor Street	Major Street	Major Street

Strategically relocating left turn movements can provide more green time to through traffic

A “Universe” of Innovative Designs

Quadrant

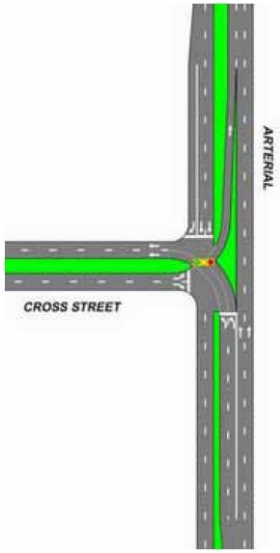
Jughandle

Roundabouts

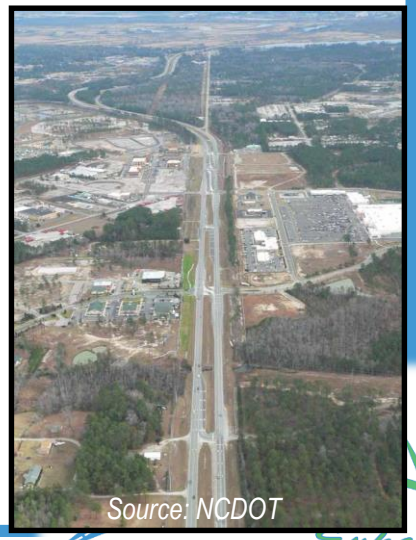
Median U-Turn

?

Green-T



Restricted Crossing U-Turn



Diverging Diamond

Displaced Left-Turn

Restricted Crossing U-Turn (RCUT)

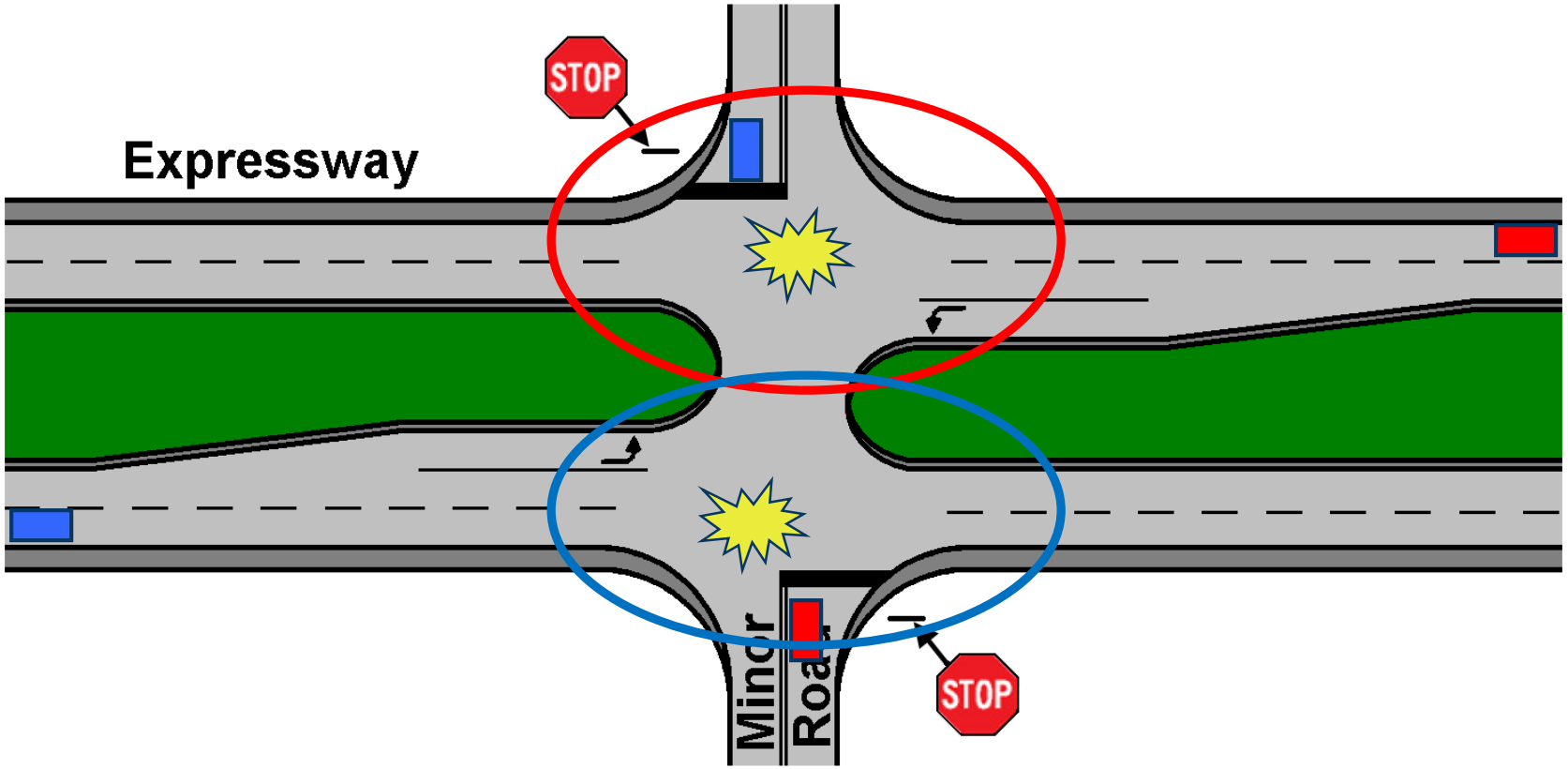
(aka J-turn, Superstreet, Reduced Conflict Intersection)

At-grade intersections with directional medians such that minor road traffic must turn right and make U-turn for the left-turn or crossing movements.

Major road typically allows all maneuvers (some variations limit left-turns).

Safety Concerns at Traditional Divided Highway Intersections

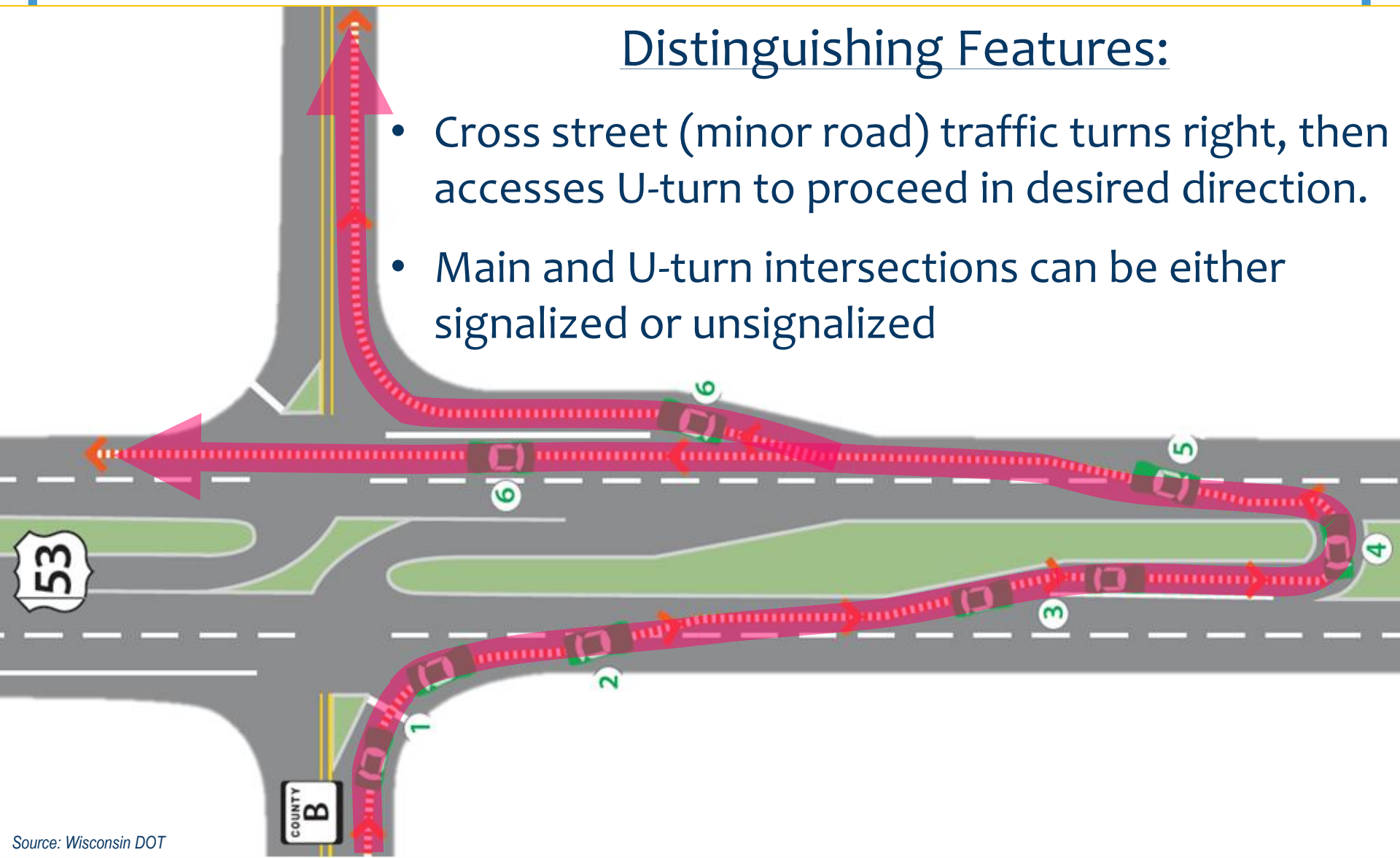
Far-Side Right-Angle Collisions



U-Turn Intersections: RCUT

Distinguishing Features:

- Cross street (minor road) traffic turns right, then accesses U-turn to proceed in desired direction.
- Main and U-turn intersections can be either signalized or unsignalized



Source: Wisconsin DOT

RCUT Intersection Field Evaluations

Maryland:

Crashes decreased 28%-44%

North Carolina:

Fatal & injury crashes decreased by 58%-85%

Tennessee (4 sites)

Before: 54 crashes (2 fatalities, 8 injuries)

After: 10 crashes
(0 fatalities, 0 injuries)

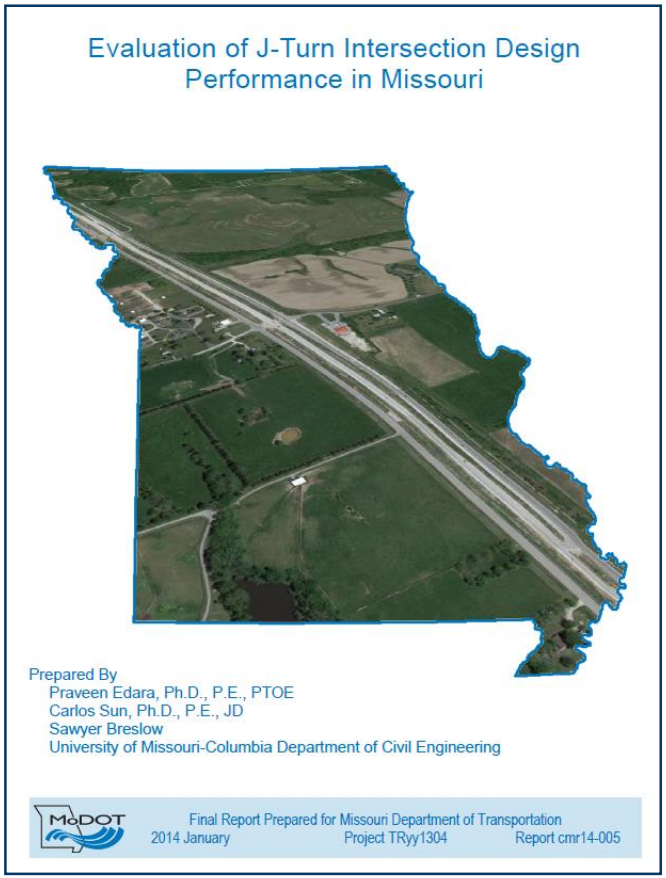
TDOT

MODOT Performance Evaluation

Analysis of 5 sites converted to J-turns

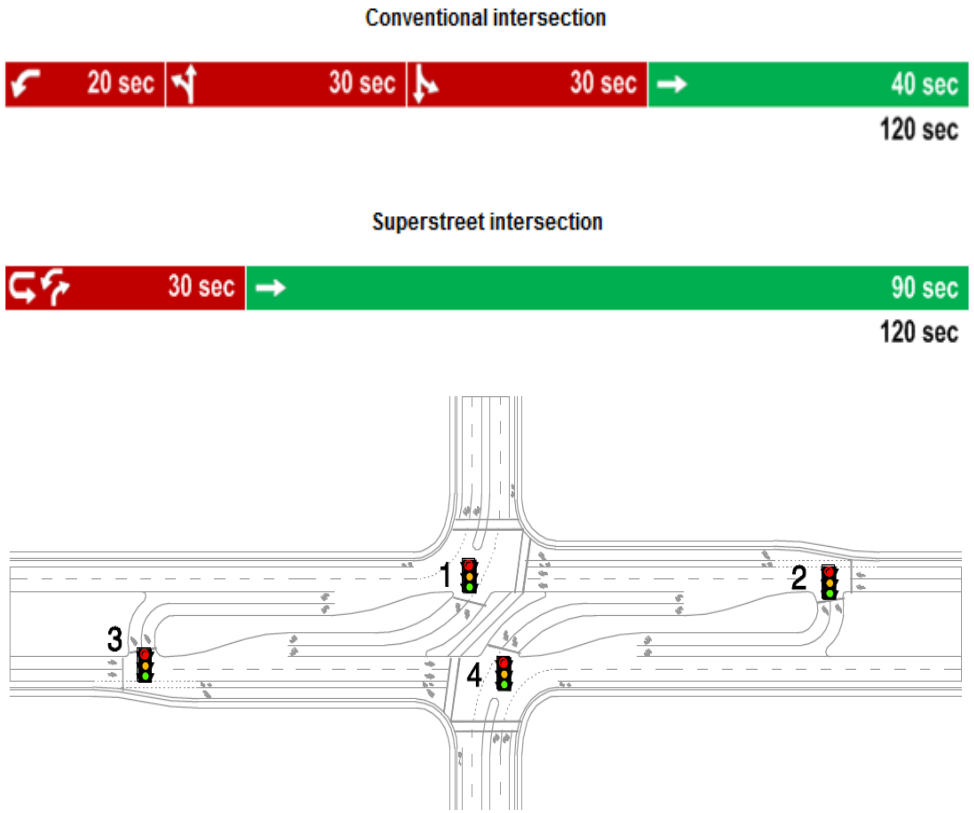
Safety Benefits:
35% total crash reduction
54% reduction in fatal & injury crashes

None of the five sites had a fatal crash following J-turn implementation



Signalized RCUT -“Superstreet”

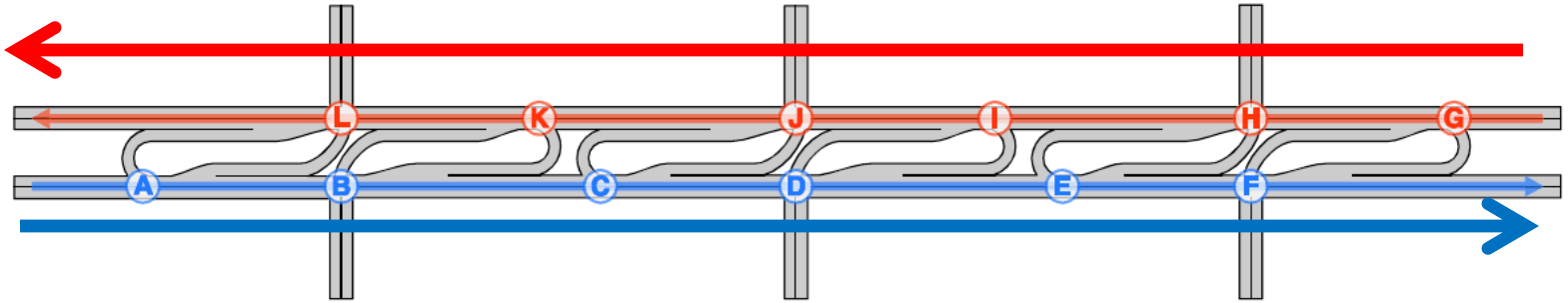
Signal operations



- RCUTs may operate with shorter cycle lengths than comparable conventional intersections because each signal will typically have only two phases
    - Shorter cycles reduce delay for most vehicles and for pedestrians
- RCUTs allow the ability to have different cycle lengths in each direction of the major street

Bi-directional progression

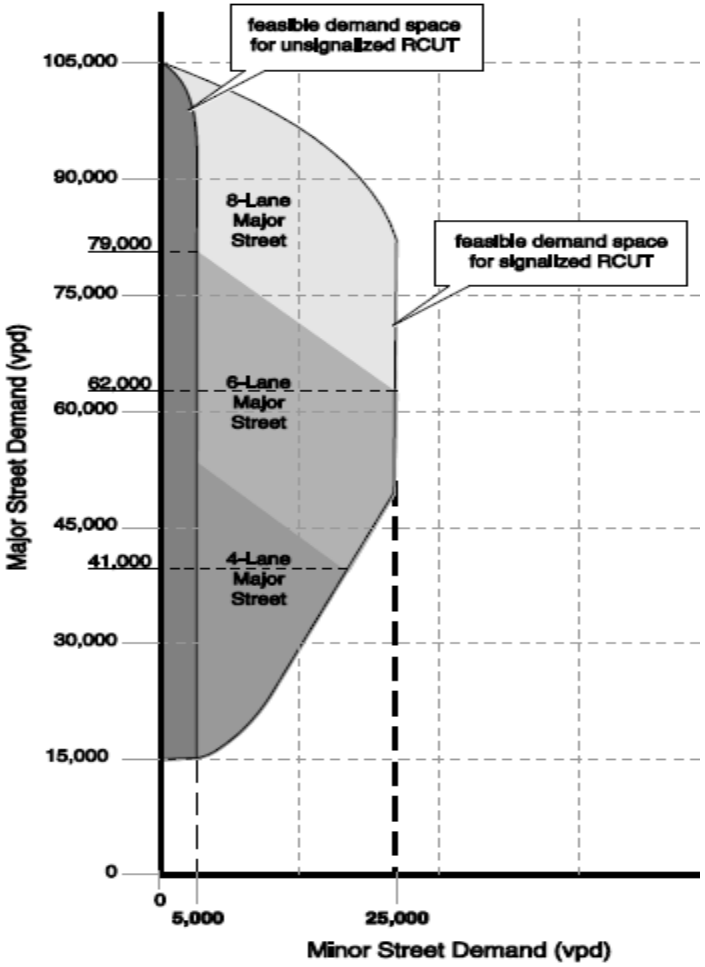
- Each direction may operate independently
- Directions can be progressed at different speeds and/or signal spacing



Direction	Parameter						
Right to left	Signal	F	E	D	C	B	A
	Distance from previous signal, ft	750	650	1000	700	600	Not applicable
	Offset to start of green, sec	74	59	46	26	12	0
Left to right	Signal	G	H	I	J	K	L
	Distance from previous signal, ft	Not applicable	600	850	1050	600	600
	Offset to start of green, sec	0	12	29	50	62	74

Note: Assumed progression speed of 50 feet per second (34 mph) in both directions

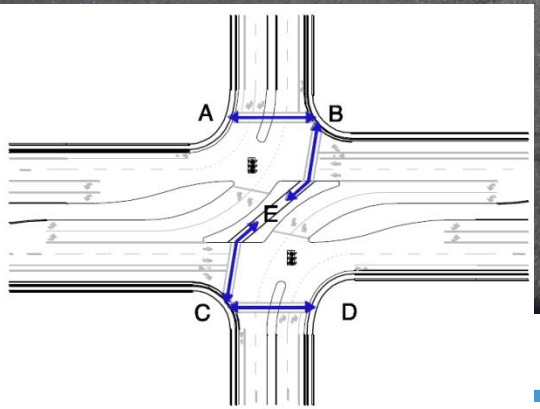
RCUT feasible demands



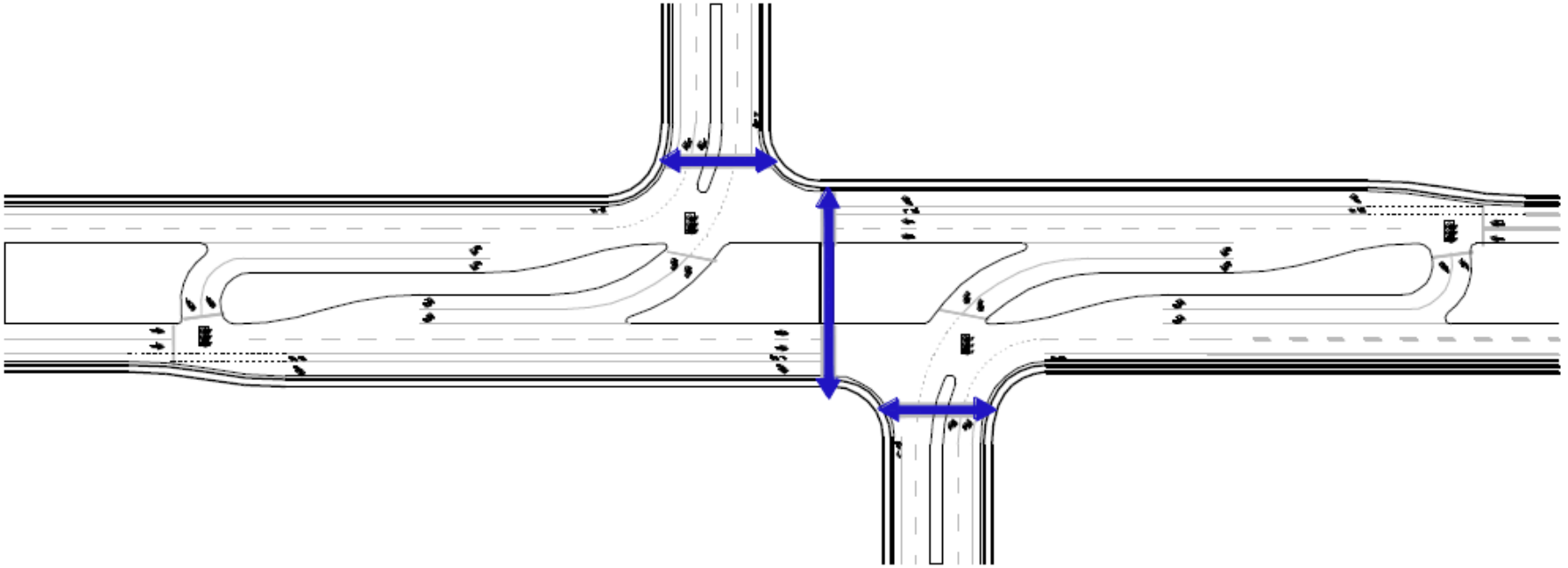
- At minor street demands below 5,000 vpd, consider unsignalized RCUTs
- For minor street demands of more than 25,000 vpd, consider other alternative intersections that would generally serve the minor street more efficiently

Source: FHWA Restricted Crossing U-Turn Informational Guide

Pedestrian crossing



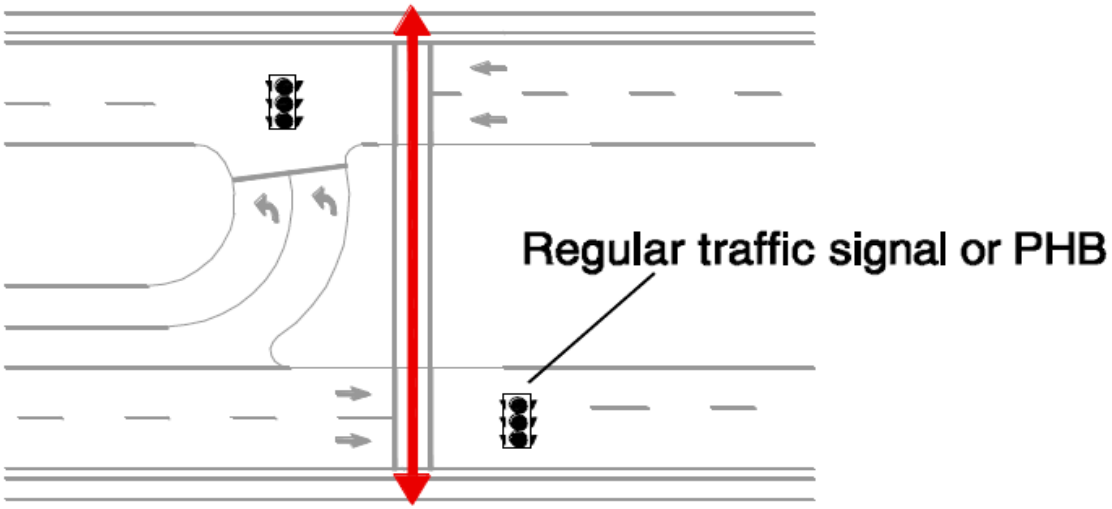
Offset approaches option



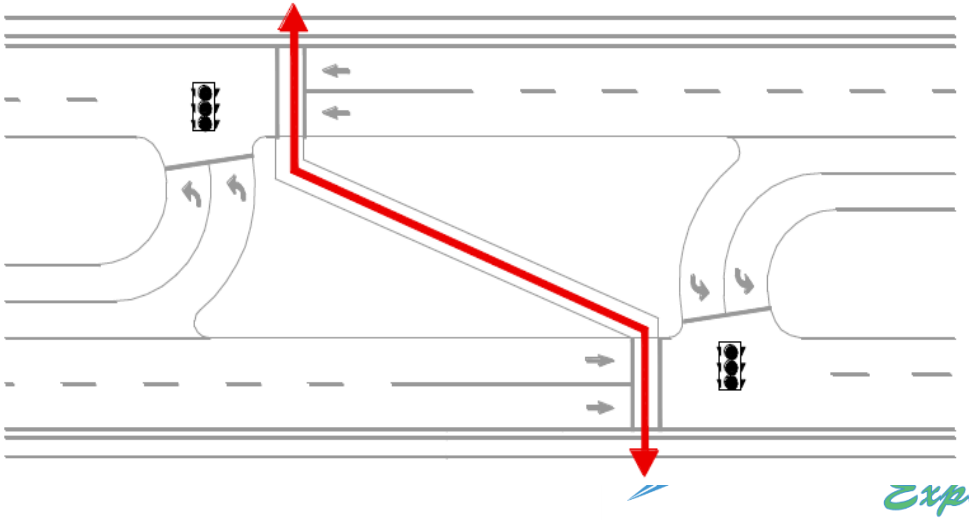
This variation should be strongly considered in developing areas where the minor street or driveway locations have not yet been established.

Wayfinding signs for pedestrians should be used to direct pedestrians to the proper crossing location.

Mid-block ped crossing option

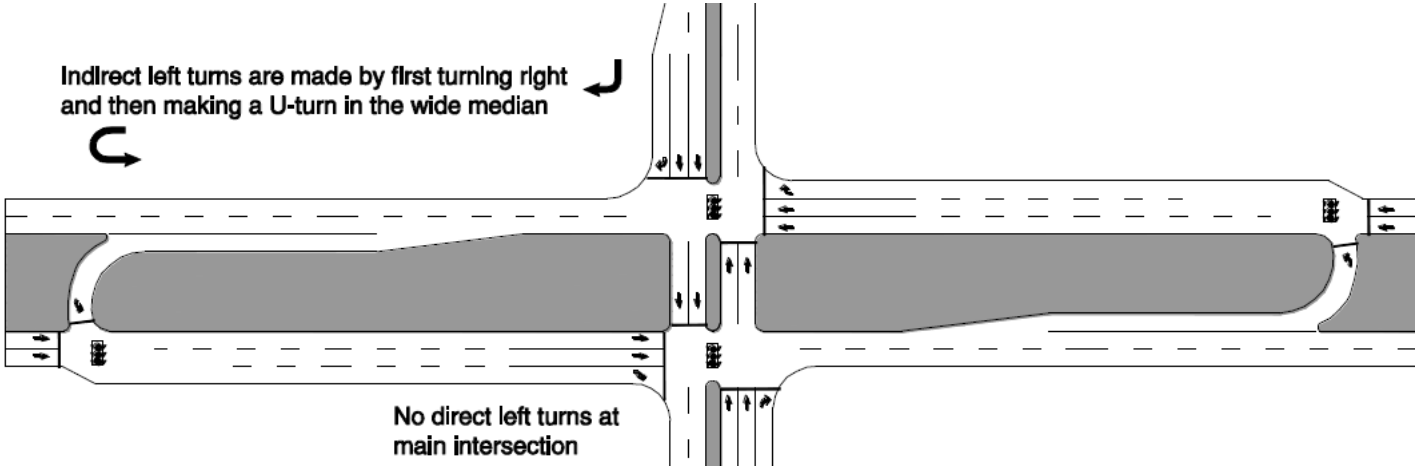


Adding pedestrian signal will not interfere with signal progression!!!



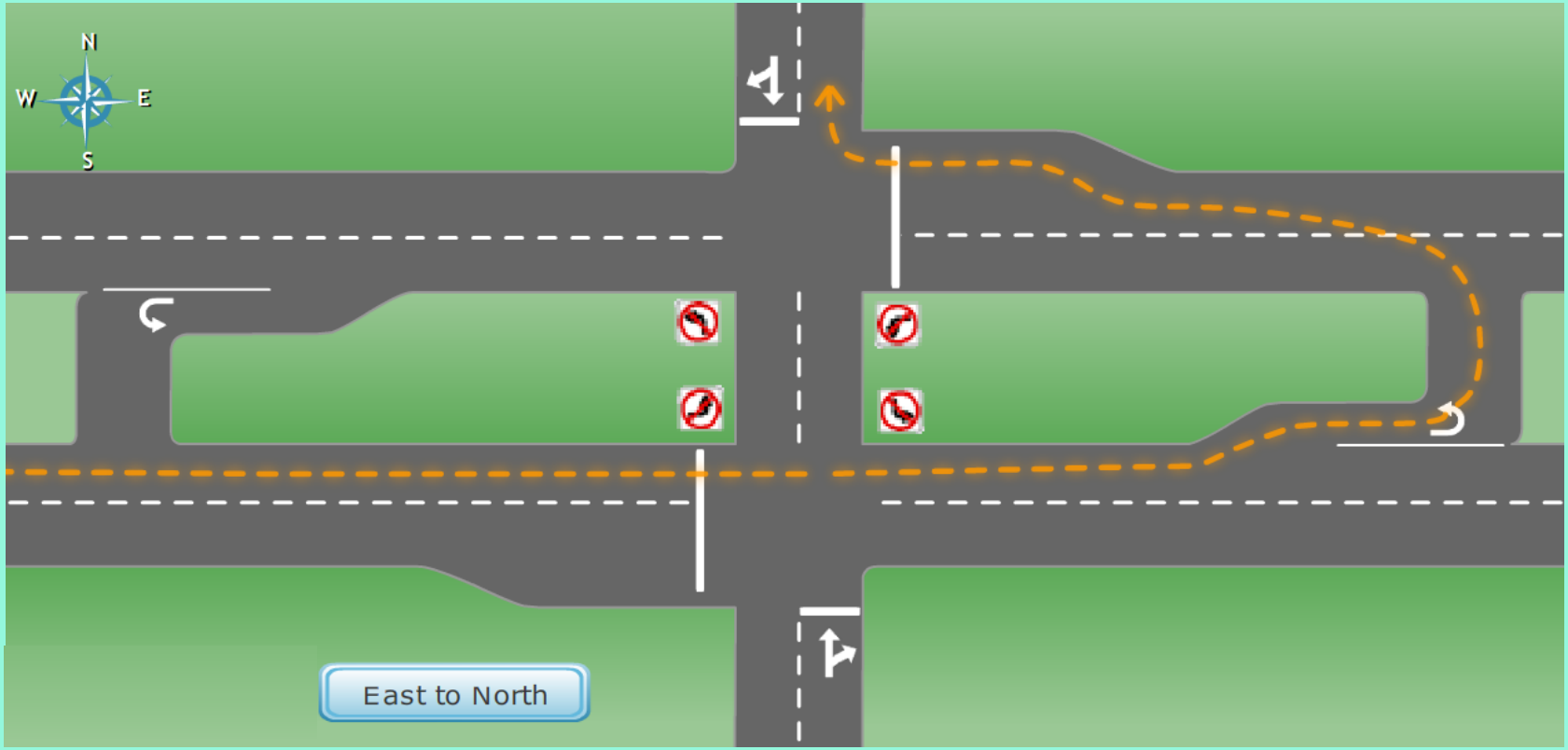
Median u-turn intersection

(aka Michigan Left)



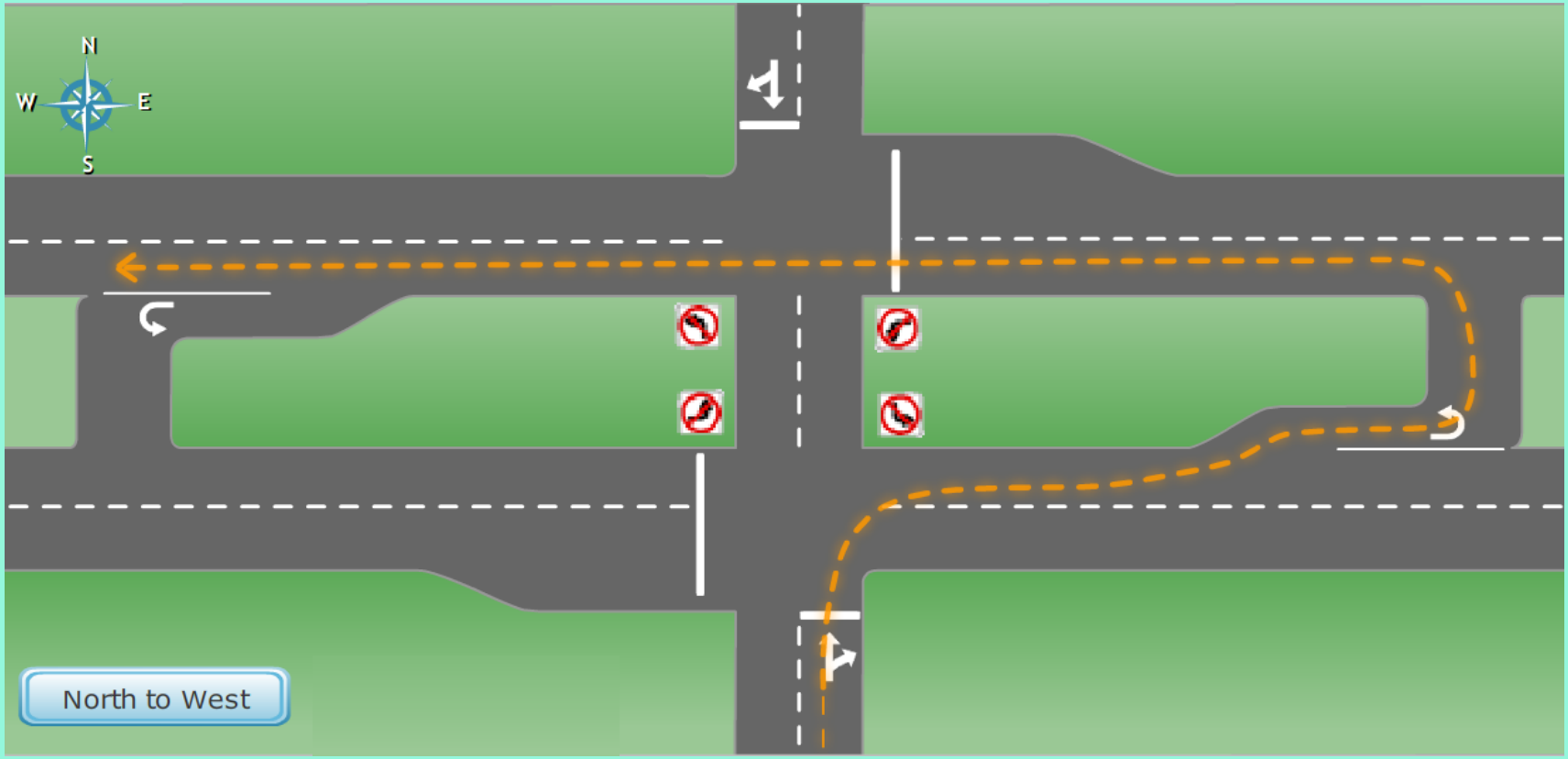
- At-grade intersections with *indirect* left turns using a U-turn movement in a wide median and/or loon
- Eliminates direct left turns on both intersecting streets, reducing the number of signal phases and conflict points at the main intersection

MUT – Left turn from major road



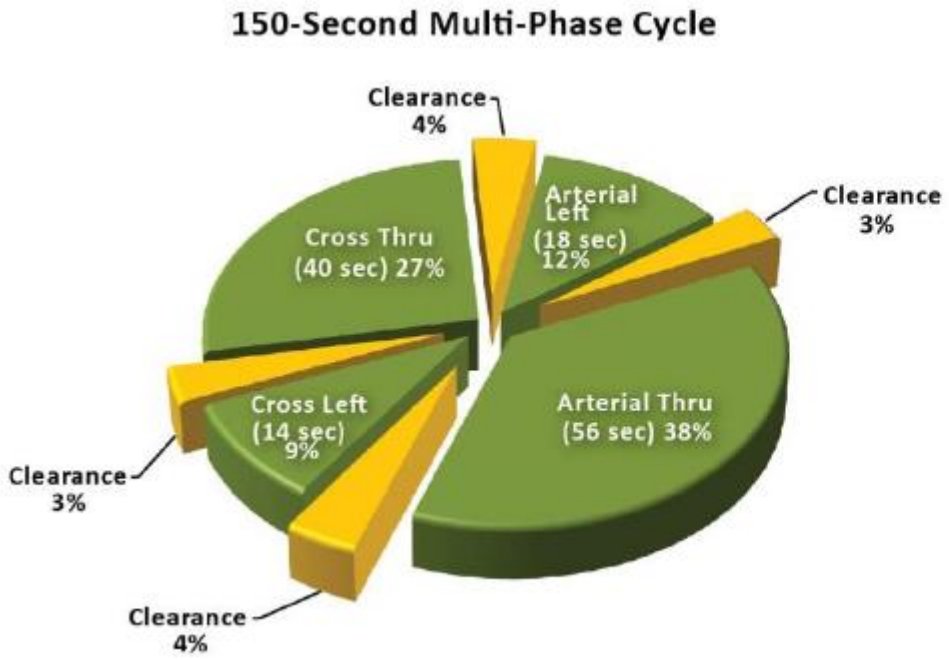
Vehicles on the major street (or the street with the median) that want to turn left are directed through the main intersection to a U-turn movement at a downstream directional crossover (usually signalized), and proceed back to the main intersection to then turn right onto the minor street.

MUT – Left turn from minor road



Vehicles on the minor street that wish to turn left at the major street are directed to turn right, make a U-turn movement at the same crossover, and then proceed through the main intersection.

MUT Signal Operations



The MUT removes left-turn phasing, which results in fewer clearance intervals in the intersection cycle and to operate well with a shorter cycle length than a comparable multi-phase cycle

Median U-Turn Corridors

MUT Corridor Performance

Based on comparative traffic operations and simulation studies, MUT intersections had the following operational advantages compared to corridors with TWLTLs and conventional intersections:

- Increase in total throughput from 20% to 40%
- Vehicles stopping were 20% to 40% lower
- Reduced travel times by 17%

MUT Safety Performance

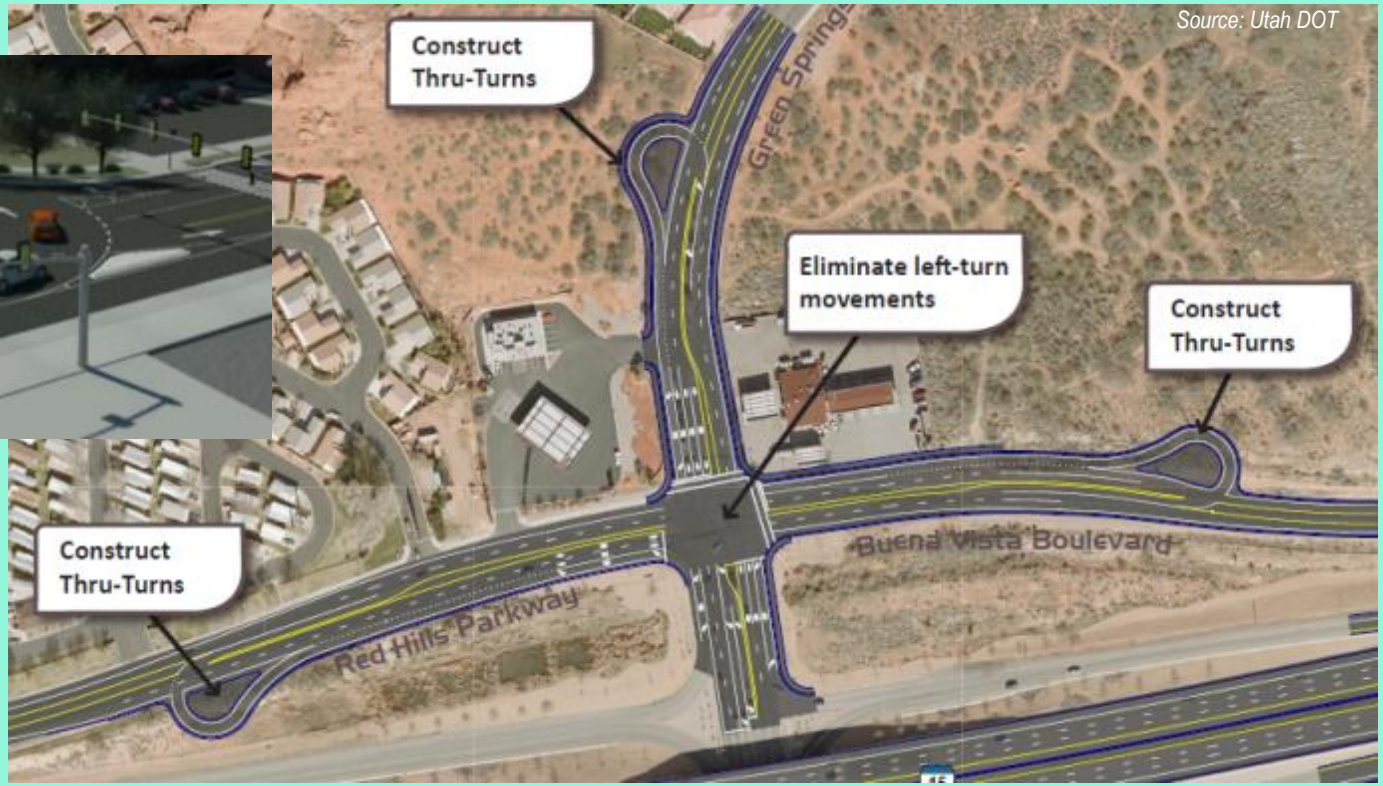
Dataset	Rate Type	Group	Mean Crash Rates (Crashes/MVE)
Corridor	All	MUT (Reduction)	1.554 (14%)
		Conventional	1.806
Intersection Related	All	MUT (Reduction)	1.388 (16%)
		Conventional	1.644
	PDO	MUT (Reduction)	0.982 (9%)
		Conventional	1.077
	Injury	MUT (Reduction)	0.407 (30%)
		Conventional	0.58

In general, MUT intersections show safety performance improvement compared to conventional intersections for most crash types and injury severities.

Source: FHWA Median U-Turn Informational Guide

OK – but …
What if I'm dealing with an existing arterial that doesn't have a median?

MUT Variations: ThrU Turn



- Similar to MUT in that direct left-turns are eliminated from main intersection
- Substitutes a paved bump-out or “loon” beyond the outside lane (or coinciding with a side-street tee intersection or driveway) for the wide median of a MUT

ThrU-Turn

- 12300 South/State Street in Draper, UT
- Adjacent to I-15 Freeway
- Three signalized U-turns 500-600 feet from intersection
- More Green Time for Thru Movements
- Reduce Congestion and Improve Safety

12300 South at State St.

Draper, UT

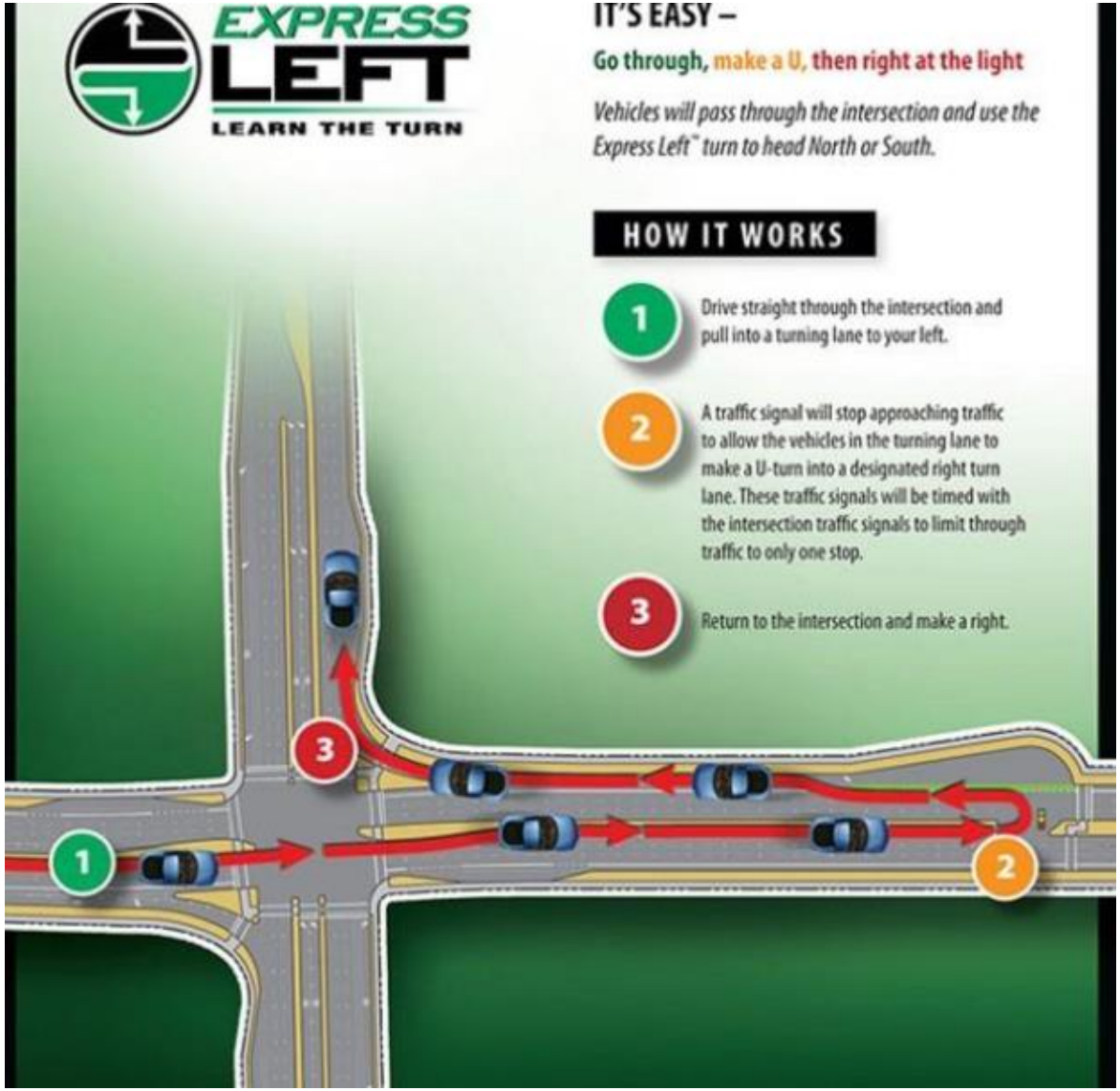
U-turn & T intersection

Draper, UT

Advance Signing at ThrU-turn

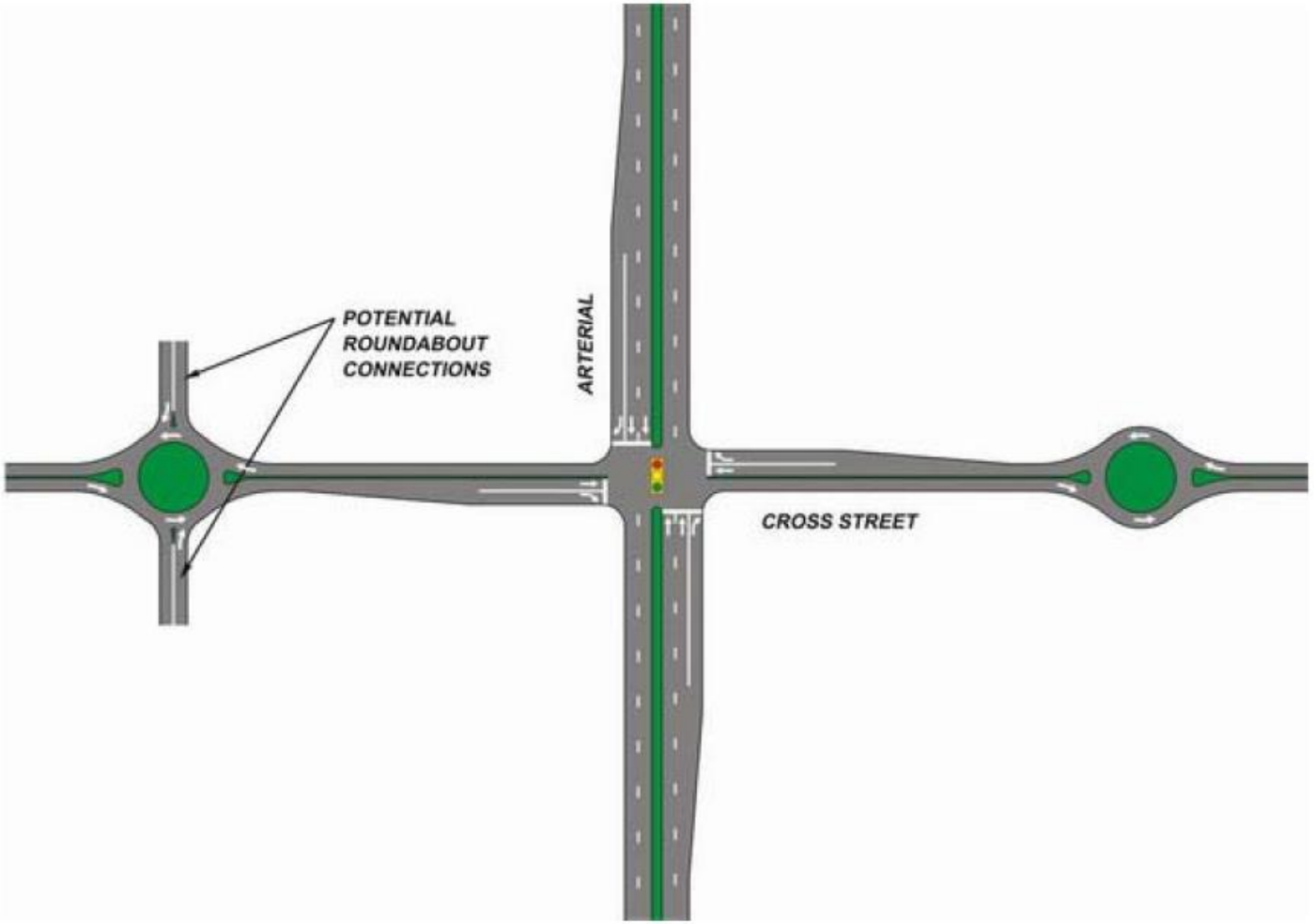
Tucson, AZ

“Express Left”

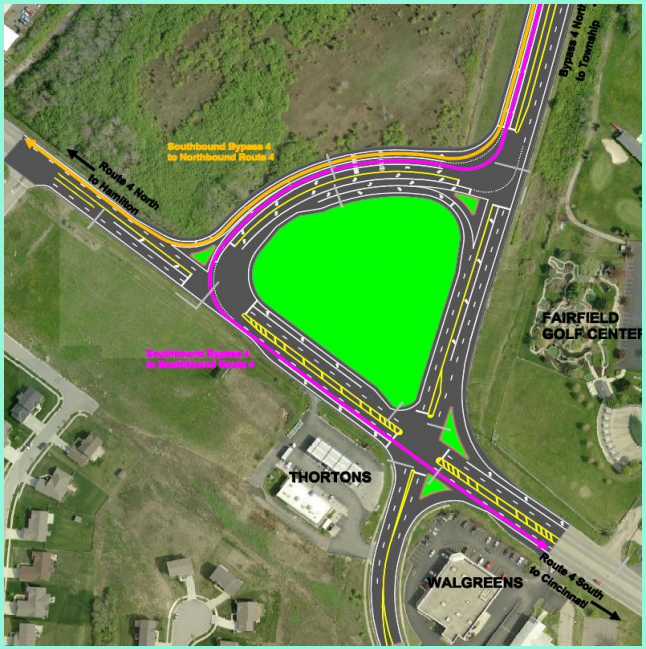


Tucson, AZ

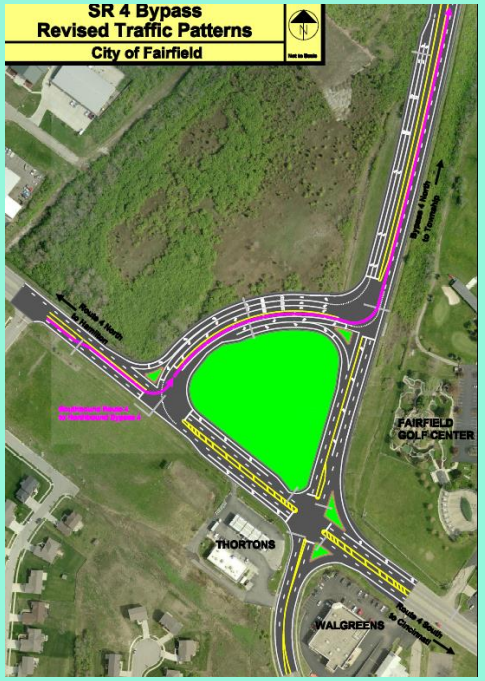
Bowtie Intersection

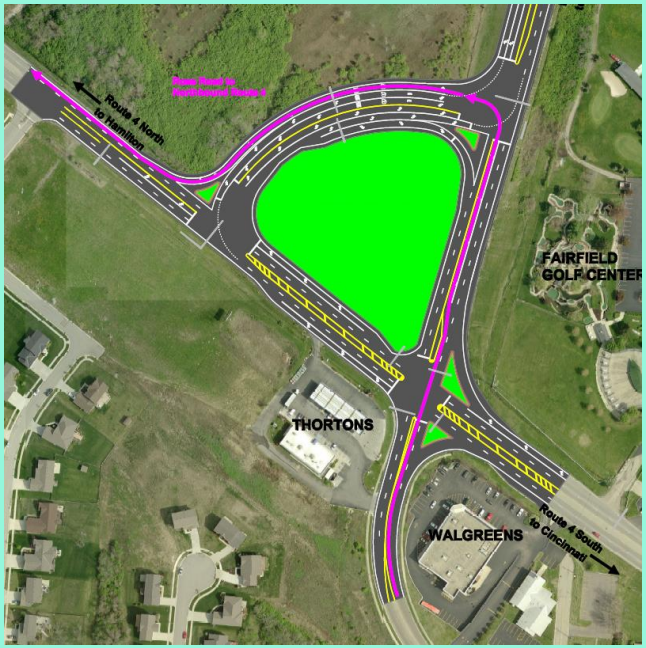


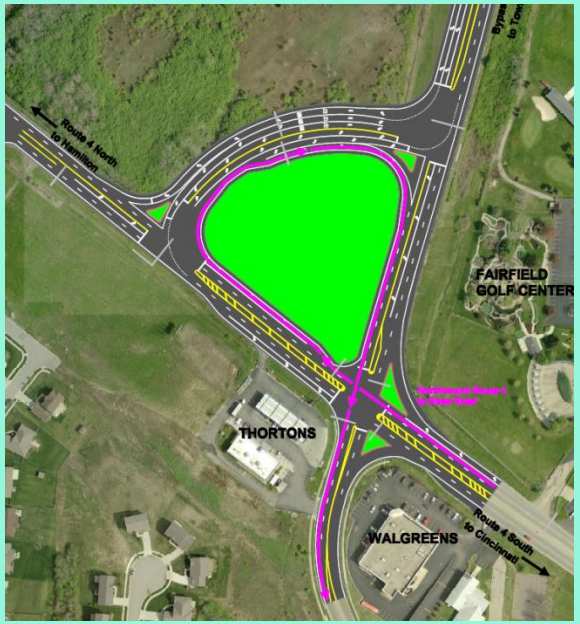
Quadrant Roadway Intersection (QRI)



All movements are provided







QRI Adjacent to Interchange

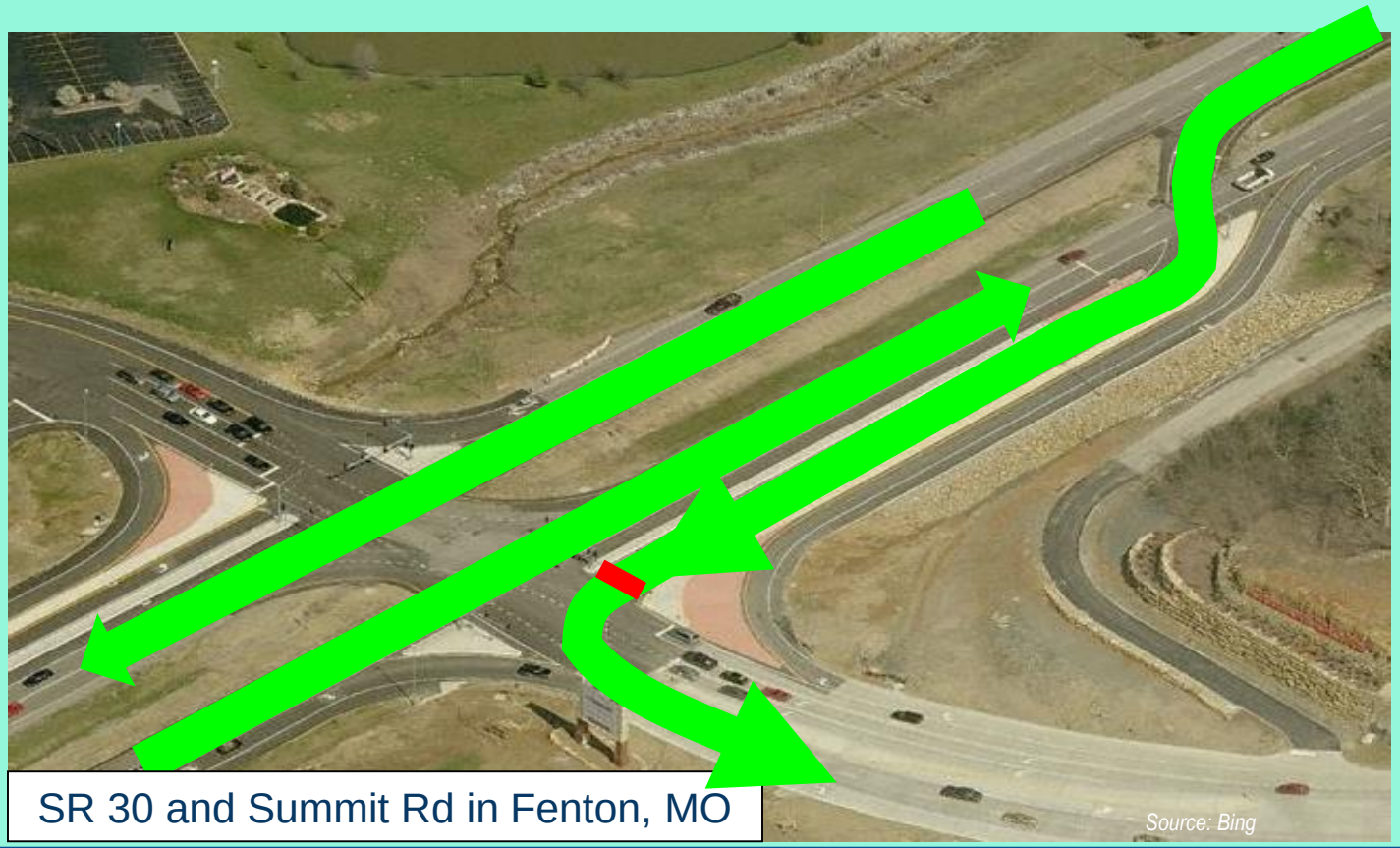

TO 21 NORTH
SOUTH
21
Sam Furr Rd
45

Jughandle Intersections

Displaced Left Turn (DLT) Intersection

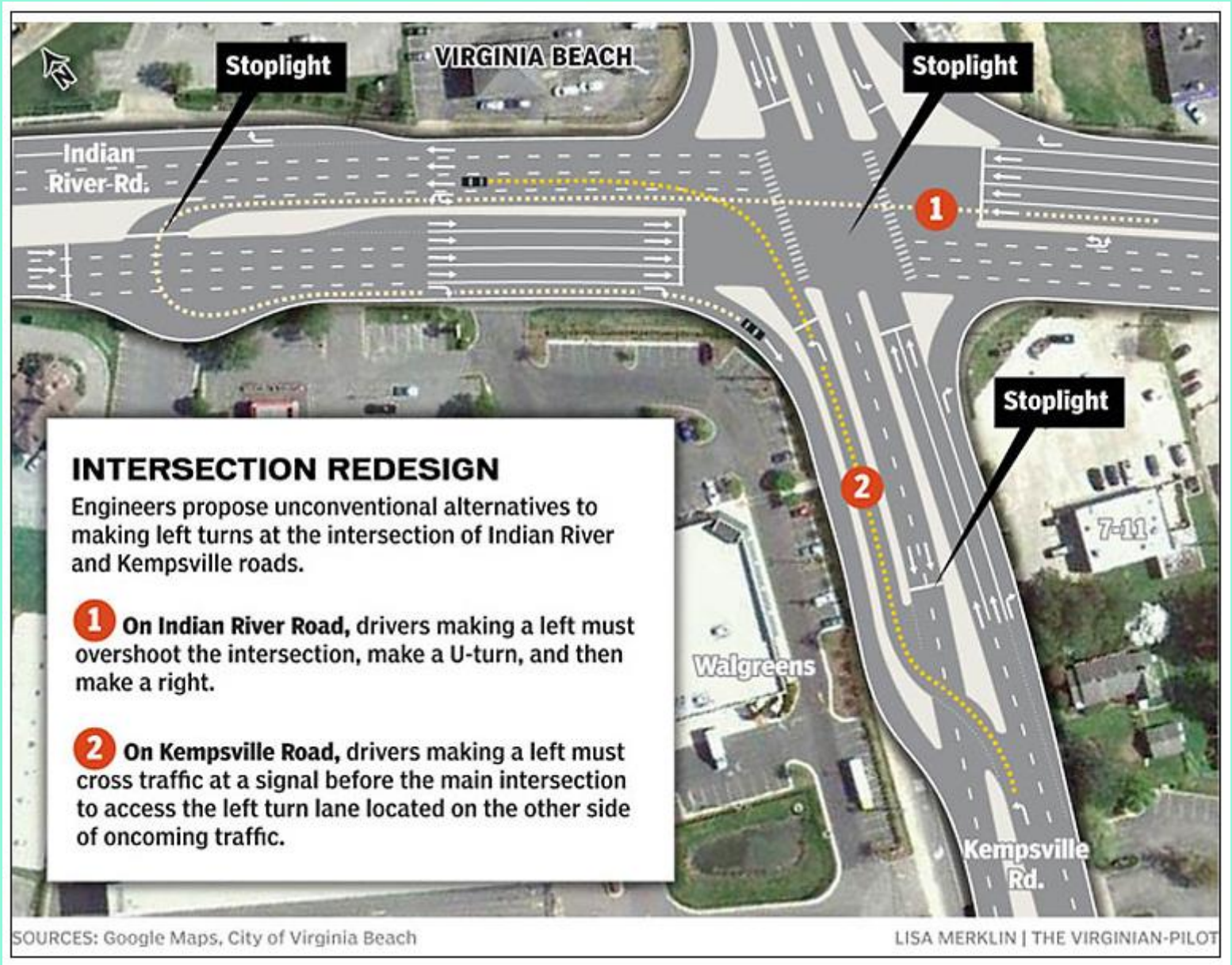
Distinguishing Feature:

Left-turn movement (on one or more approaches) strategically relocated to the far-side of the opposing roadway via interconnected signalized crossover in advance of the main intersection

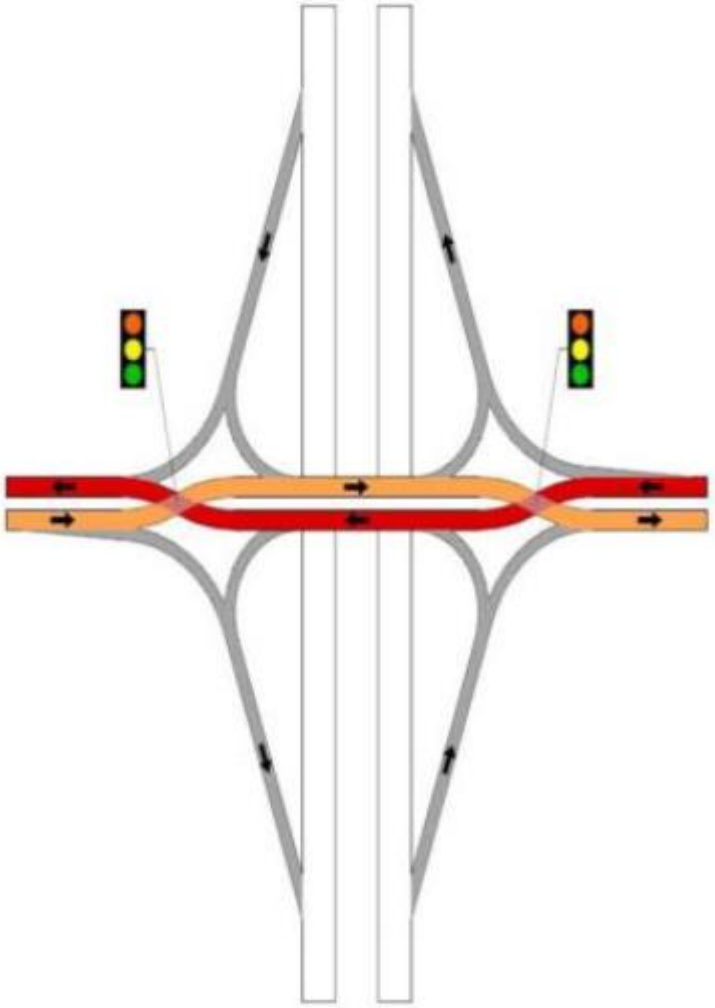


SR 30 and Summit Rd in Fenton, MO

DLT & ThrU Turn Combo



Diverging diamond interchange (DDI)



A diamond interchange form that allows the two directions of traffic on the crossroad to temporarily divide and cross to the opposite side to gain access to and from the freeway more easily

I-44 and SR-13
Springfield, MO
Opened July 2009

As of May 2016:
65 DDIs open and operational in USA
Many more in construction or design

Benefits of innovative Intersection Geometrics

SAFETY

- **Fewer conflict points**
- **Significant Before/After Crash Reductions**

MOBILITY

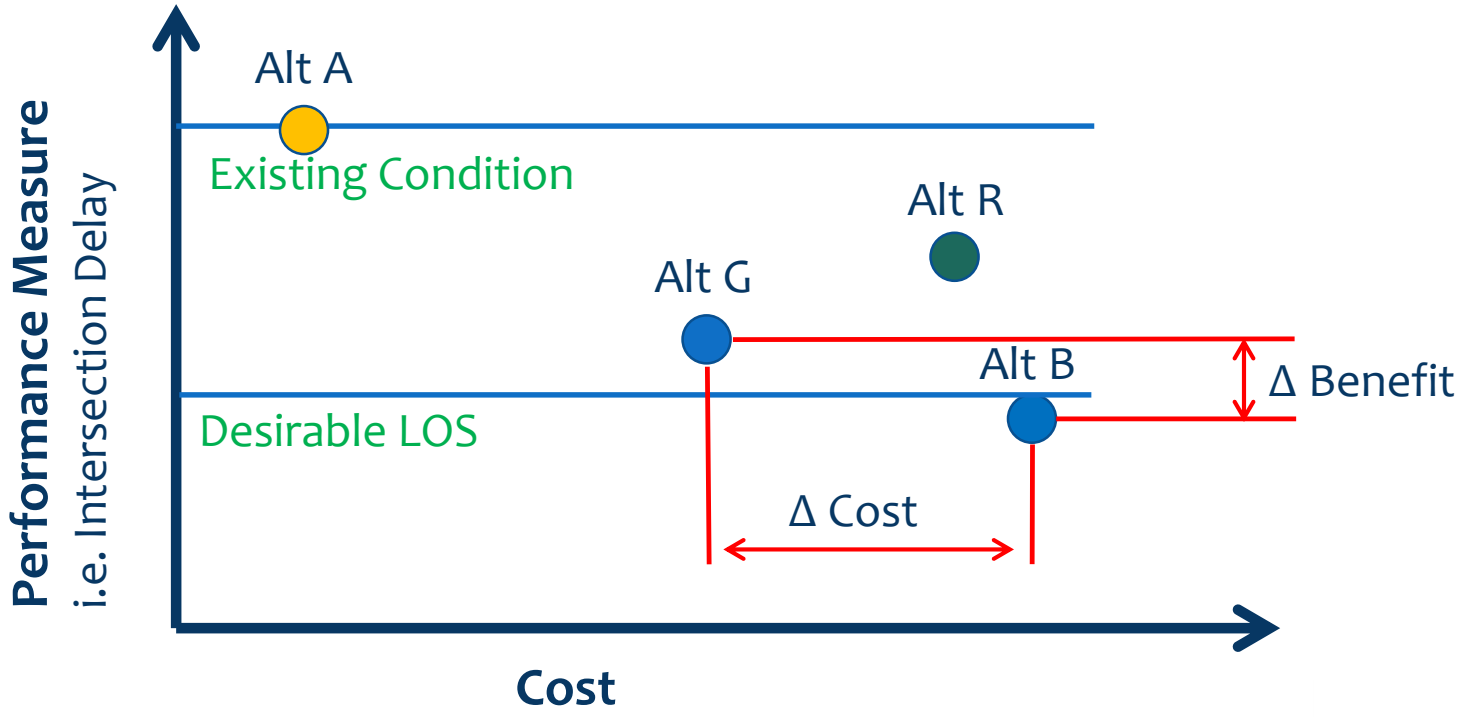
- **Less delay**
- **Reduced congestion**

VALUE

- **Less ROW**
- **Less construction costs**
- **Implemented quicker**

Interpreting “value”

Hypothetical Cost-Effectiveness Graph of Four Alternatives

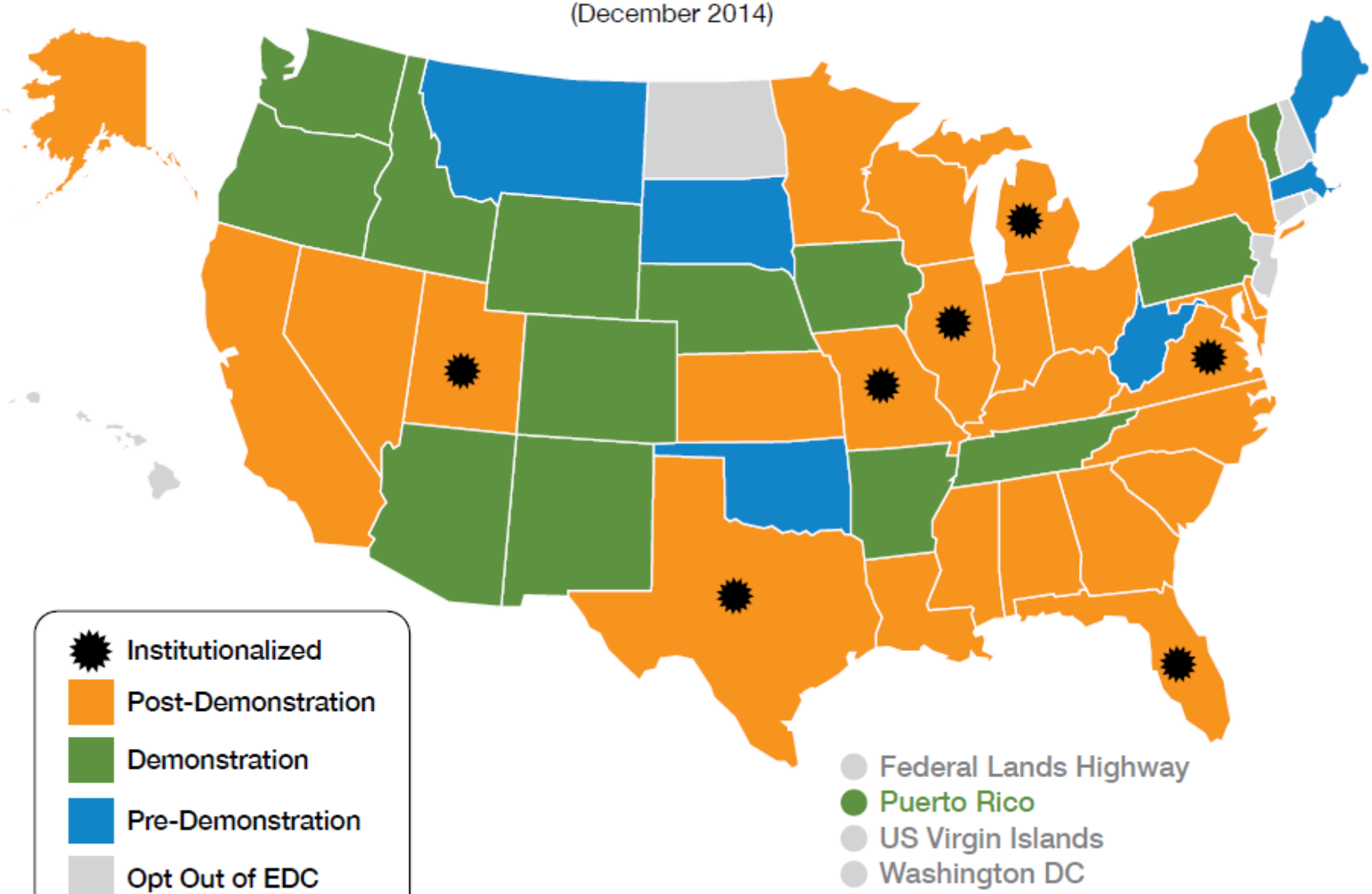


EDC2 Crossing the "Finish Line" in 2015

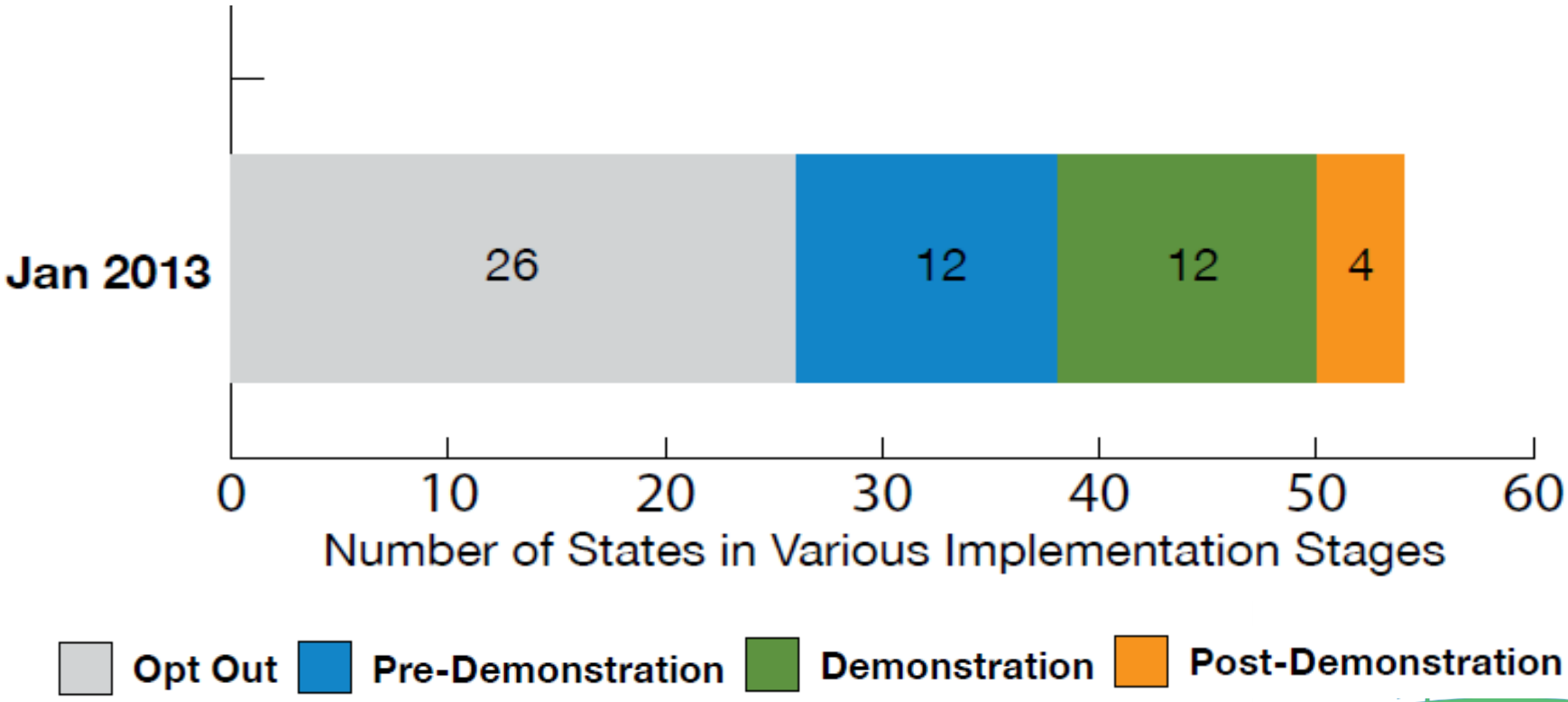
2016 Design Training Expo

Intersection and Interchange Geometrics

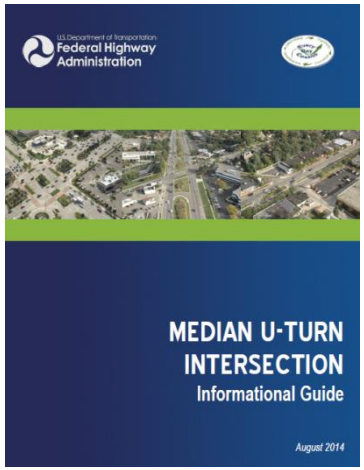
(December 2014)

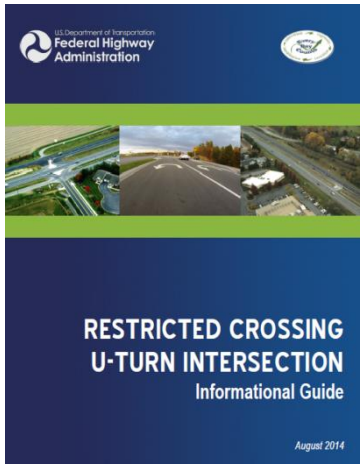


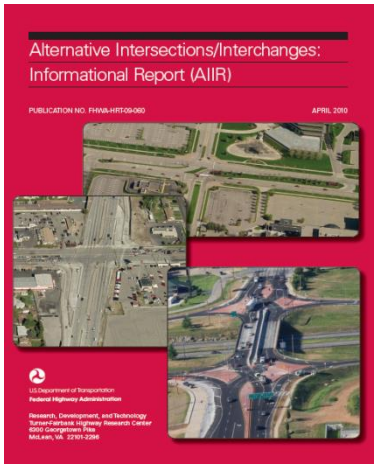
Intersection and Interchange Geometrics



Resources

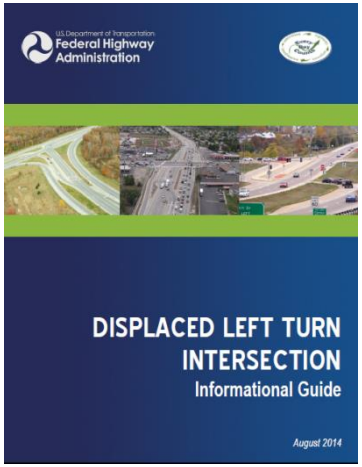


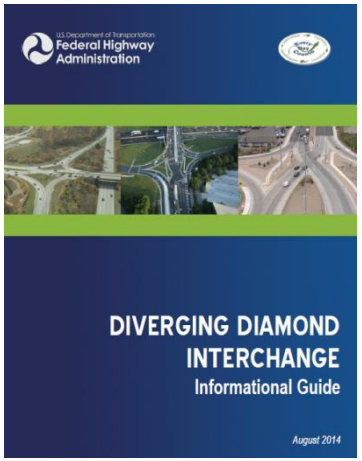


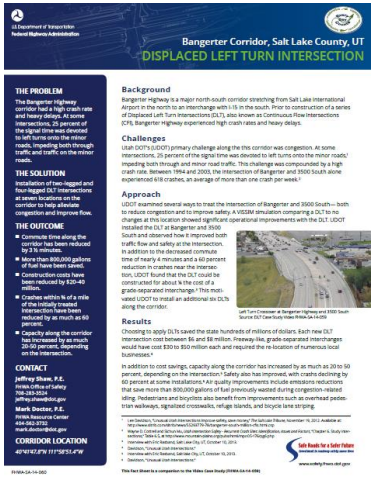


For easy access …

safety.fhwa.dot.gov/intersection/







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2016 Design Training Expo